INDIANA DEPARTMENT OF TRANSPORTATION

STANDARDS COMMITTEE MEETING AGENDA

Driving Indiana's Economic Growth

January 21, 2008

MEMORANDUM

TO: Standards Committee

FROM: Mike Milligan, Secretary

RE: Minutes for the January 17, 2008 Standards Committee Meeting

The Standards Committee meeting was called to order by the Chairman at 9:05 a.m. on January 17, 2008 in the N955 Bay Window Conference Room. The meeting was adjourned at 11:20 a.m.

The following members were in attendance:

Mark Miller, Chairman
Dennis Kuchler, State Constr. Engr.
Ron Heustis, Constr. Mgmt.
Larry Rust, Traffic Control
Ron Walker, Materials Mgmt.
Shakeel Baig, Crawfordsville Dist.
Dave Andrewski, Pvmt. Engineering
Bob Cales, Contract Admin.
John Wright, Roadway Services
Anne Rearick, Structural Services
Jim Keefer, Fort Wayne Dist.

Also in attendance were the following:

Mike Milligan, Secretary
Todd Shields, INDOT
Tony Uremovich, INDOT
Tom Duncan, FHWA
Paul Berebitsky, ICA

New Business

Item No.	Sponsor	Page No.
Item 08-6-1 404 Action:	Mr. Andrewski SEAL COAT Withdrawn	3
Item 08-6-2 *412* Action:	Mr. Walker *FOG SEAL* Passed as revised	9
Item 08-6-3 902.01(b) Action:	Mr. Walker Asphalt Emulsions Passed as submitted	11

Item 08-6-4	Ms. Rearick	13
911.01	Untreated Lumber	
911.01(a)4	*Sawn* Timbers	
911.01(a)8	Rough *Sawn* Lumber	
Action:	Passed as submitted	
Item 08-6-5	Ms. Rearick	14
Design Manual	Part VI, Structural Design: Chapters 61, 62, 63, 65, 67 Changes to Complement AASHTO LRFD	
Action:	Passed as revised	

General Points of Discussion:

Mark Miller, Committee Chair, mentioned that he would begin to check for a meeting quorum before each meeting to facilitate a prompt start to the meeting.

Tom Duncan, FHWA, suggested that the Standards Committee should consider performance specifications whenever possible.

Ron Heustis, Manager, Construction Technical Support, announced that he had sent a draft Standards Committee Process to committee members, but had not received any comments. Ron urged members to review the draft process and comment. He plans to put together a final process soon.

cc: Committee Members (11)
FHWA (1)

REVISION TO 2008 STANDARD SPECIFICATIONS

SECTION 404, BEGIN LINE 1, DELETE AND INSERT AS FOLLOWS:

SECTION 404 – SEAL COAT

404.01 Description

This work shall consist of one or more applications of asphalt material, each followed by an application of cover aggregate in accordance with 105.03.

MATERIALS

404.02 Asphalt Material

The type and grade of asphalt material shall be in accordance with the following:

Asphalt Emulsion, RS-2, AE-90, AE-90S, or HFRS-2..........902.01(b)

404.03 Cover Aggregate

Aggregate shall be in accordance with the following requirements. When slag is used as an alternate to natural aggregate, adjustments will be made in accordance with 904.01, to compensate for differences in specific gravity.

Coarse Aggregates, Class B or Higher
Size No. 8, 9, 11, or 12 904
Fine Aggregate
Size No. 23 or 24 904

The types of seal coats shall be as follows:

TYPE	APPLICATION	COVER AGGREGATE SIZE NO. AND COURSE	RATES OF APPLICATION PER SQUARE YARD (SQUARE METER)	
			AGGREGATE lb (kg)	ASPHALT MATERIAL GALLON (LITER) AT 60°F (16°C)
1*	Single	23, 24	12-15 (5.4-6.8)	0.12-0.16 (0.45-0.61)
2	Single	12	14-17 (6.4-7.7)	0.29-0.33 (1.09-1.25)
3	Single	11	16-20 (7.3-9.1)	0.36-0.40 (1.36-1.51)
4	Single	9	28-32 (12.7-14.5)	0.63-0.68 (2.38-2.57)
5	Double	Top – 12 Bottom – 11	16-19 (7.3-8.6) 16-20 (7.3-9.1)	0.33-0.37 (1.25-1.40) 0.36-0.40 (1.36-1.51)
6	Double	Top – 11 Bottom – 9	18-22 (8.2-10.0) 28-32 (12.7-14.5)	0.41-0.46 (1.55-1.74) 0.63-0.68 (2.38-2.57)
7	Double	Top – 11	18-22 (8.2-10.0)	0.41-0.46 (1.55-1.74)

		Bottom – 8	28-32 (12.7-14.5)	0.63-0.68 (2.38-2.57)

~~* Only AE-90 or AE-150 shall be used for seal coat, type 1~~. ** Note – HFRS-2 shall not be used with Type 1 Seal Coat*

CONSTRUCTION REQUIREMENTS

404.04 Weather Limitations

Asphalt material shall not be applied on a wet surface, or when other weather conditions would adversely affect the seal coat~~s~~. Seal coat~~s~~ shall not be placed when the ambient or base temperature is below ~~40°F (4°C~~) *60°F (14°C)*. ~~If seal coats are placed when the ambient or base temperature is between 40°F (4°C) and 60°F (16°C), the cover aggregate shall be heated to between 120°F (49°C) and 150°F (66°C)~~. *Seal coat shall not be applied to mainline traffic lanes before May 1 or after October 1, but may be applied to shoulders within the above temperature range.*

404.05 Equipment

A distributor, rotary power broom, pneumatic tire roller, and aggregate spreader in accordance with 409.03 shall be used.

404.06 Preparation of Surface

Surfaces to be sealed shall be *patched as required,* brought to proper section and grade, *and* compacted.~~, cleaned as required, and approved.~~

The surface shall be cleaned prior to seal coat application. The pavement shall be swept clean of all loose material using a rotary power broom. Depressions or material not removed by the brooming operation shall be cleaned by hand. Sealing operations may not commence until the Engineer approves the surface.

All castings and raised pavement markings shall be covered with suitable material prior to sealing. These coverings shall be removed prior to opening to traffic.

404.07 Applying Asphalt Material

Asphalt material shall be applied in a uniform continuous spread over the section to be treated. The quantity of asphalt material to be applied per square yard (square meter) shall be as ~~directed~~ *required. During application, minor adjustments to the application rate shall be made as needed to obtain the optimum results for the material used and existing surface condition.*

The asphalt material shall not be spread over a greater area than that which can be covered with the cover aggregate that is in trucks at the site. ~~It shall not be spread more than 500 ft (150 m) ahead of the aggregate spreader.~~

The spread of the asphalt material shall be no wider than the width covered by the cover aggregate from the spreading device. Operations shall not proceed such that asphalt material is allowed to chill, set up, dry, or otherwise impair retention of the cover coat.

404.08 Application of Cover Aggregate

~~Immediately following~~ *Within 1 minute of* the application of the asphalt material, cover aggregate shall be spread in quantities as ~~directed~~ *required*. Spreading shall be accomplished such that the tires of the trucks or aggregate spreader do not contact the uncovered and newly applied asphalt material.

~~Rolling shall consist of at least three complete roller coverages and be completed within 30 min after the cover aggregate is applied. The rollers shall not be operated at speeds that will displace the cover aggregate from the asphalt material.~~

~~The seal coat shall be protected by the restriction of traffic or by controlling traffic speed until the asphalt material has cured or set sufficiently to hold the cover aggregate without displacement.~~

~~Excess cover aggregate shall be removed from the pavement surface by light brooming on the day following placement of the seal coat. The brooming shall not displace the imbedded aggregate.~~

404.09 Rolling Operation

The aggregate shall be seated with at least three complete roller coverages. The first coverage shall be completed within 2 min of aggregate application, with the final coverage completed within 30 min after the cover aggregate is applied. The rollers shall not be operated at speeds that will displace the cover aggregate from the asphalt material.

404.10 Sweeping Operation

Excess cover aggregate shall be removed from the pavement surface by light brooming on the same day of placement of the seal coat, after the asphalt material has sufficiently set. The brooming shall not displace the imbedded aggregate. A second brooming operation shall be performed the next day.

404.11 Protection of Surface

Traffic shall not be permitted on freshly sealed surfaces until final rolling is complete. Traffic speed will be limited to a maximum of 25 MPH by use of pilot vehicles or other means for a minimum of 2 hours after completion of the rolling operation. This time will be extended if the asphalt material has not cured sufficiently to prevent dislodging of the cover aggregate.

Any areas with minor bleeding will be covered with fine aggregate or other approved blotting material.

404.~~09~~*12* Method of Measurement

~~Asphalt material and cover aggregate will be measured by the ton (megagram).~~ Seal coat will be measured by the square yard (square meter).

~~If measurement of seal coat is made by the square yard (square meter), the~~ *The* quantity for each day's placement will be the least of the following:

(a) the measured square yards (square meters) within the specified limits;

(b) the calculated square yards (square meters) based on the amount of aggregate used, divided by the minimum amount of aggregate per square yard (square meter) specified in 404.03; or

(c) the calculated square yards (square meters) based on the amount of asphalt material used, divided by the minimum amount of asphalt material per square yard (square meter) specified in 404.03.

404.~~10~~*13* Basis of Payment

~~The accepted quantities of asphalt material and cover aggregate will be paid for at the contract unit price per ton (megagram).~~ Seal coat will be paid for at the contract unit price per square yard (square meter) complete in place. ~~If slag is used as a cover aggregate, and payment will be made per ton (megagram), the pay quantity will be adjusted in accordance with 904.01.~~

~~If seal coat is paid for by the square yard (square meter) and if so directed, asphalt material in excess of the limits set out in 404.03 will be paid for at the Contractor's invoice price, plus 20%.~~

Payment will be made under:

Pay Item	**Pay Unit Symbol**
~~Asphalt for Seal Coat~~	~~TON (Mg)~~
~~Cover Aggregate, Seal Coat~~	~~TON (Mg)~~
Seal Coat, ______ type	SYS (m2)

The cost of determination of asphalt material and cover aggregate application rates, sweeping and rolling operations, providing pilot vehicles, blotting material, and other incidentals shall be included in the costs for the pay item.

SECTION 404, CONTINUED.

COMMITTEE COMMENTS ON THIS ITEM:

Item withdrawn – to be reviewed by 400 Committee prior to resubmittal.

Other sections containing specific cross references: SEE NEXT PAGE	General Instructions to Field Employees Update Required? Y___ N___ By - Addition or Revision Frequency Manual Update Required? Y___ N___ By - Addition or Revision
Recurring Special Provisions potentially affected: None	Standard Sheets potentially affected: None
Motion: M Second: M Ayes: Nays:	Action: Withdrawn

OTHER SECTIONS CONTAINING SPECIFIC CROSS REFERENCES:

REVISION TO 2008 STANDARD SPECIFICATIONS

SECTION 412, BEGIN LINE 1, INSERT AS FOLLOWS:

SECTION 412 – FOG SEAL

412.01 Description

This work shall consist of applying asphalt emulsion to the pavement surface in accordance with 105.03.

MATERIALS

412.02 Materials

Materials shall be in accordance with the following:

Asphalt Emulsion, AE-PL..902.01(b)
Fine Aggregate...904.02

CONSTRUCTION REQUIREMENTS

412.03 Equipment

A distributor in accordance with 409.03(a) shall be used.

412.04 Weather Limitations

Fog seal operations shall not be conducted on a wet pavement, when the ambient air or pavement temperature is below 60°F (16°C), or when other unsuitable conditions exist, unless approved by the Engineer. Fog seal shall not be applied to travel or auxiliary lanes before May 1 or after October 1.

412.05 Preparation of Surface

Surfaces shall be clean and free of any foreign or loose material.

All castings, detector housings, and snowplowable raised pavement markers shall be covered to prevent coating with fog seal prior to application of the fog seal. These coverings shall be removed prior to opening to traffic.

412.06 Application of Asphalt Material

The asphalt material shall be applied uniformly at a rate within ± 0.02 gal./syd (0.065 L/sq m) of the rate shown on the plans. Asphalt material shall be applied in such a way as to ensure even and uniform coverage to the pavement surface.

412.07 Protection of Surface

Fine aggregate or other approved blotting material shall be applied to pedestrian crosswalks, driveways or other areas as directed by the Engineer. Brooming of ponded areas shall be required prior to placing traffic on treated surfaces, as directed.

Traffic shall not be permitted on the freshly sealed surface until the asphalt material has sufficiently cured to prevent tracking.

SECTION 412, CONTINUED.

412.08 Method of Measurement

Fog seal will be measured by the square yard (square meter) complete in place.

412.09 Basis of Payment

Fog seal will be paid for at the contract unit price per square yard (square meter).

Payment will be made under:

Pay Item	***Pay Unit Symbol***
Fog Seal	*SYS (m2)*

The costs of all asphalt materials, fine aggregate, surface preparation, and all other necessary incidentals shall be included in the cost of the pay item.

COMMITTEE COMMENTS ON THIS ITEM:

Implement Item 08-6-2 with Item 08-6-3 as one recurring special provision only. To be reviewed in approximately one year for consideration of inclusion in 2010 Standard Specifications.

Other sections containing specific cross references:

None

General Instructions to Field Employees
Update Required? Yes
By - Addition
Frequency Manual
Update Required? No

Recurring Special Provisions potentially affected:

None

Standard Sheets potentially affected:

None

Motion: Mr. Walker
Second: Mr. Cales
Ayes: 10
Nays: 0

Action: Passed as revised

_x_ RSP Effective: July 1, 2008 Letting
___ RPD Effective: ____________ Letting
___ 20__ Standard Specifications Book
___ 20__ Standards Edition
___ 20__ Design Manual
___ Technical Advisory

Received FHWA Approval? Yes

Item No. 08-6-3
Mr. Walker
Date: 01/17/08

REVISION TO 2008 STANDARD SPECIFICATIONS

SECTION 902, BEGIN LINE 125, INSERT AS FOLLOWS:

Characteristic [1] [2]	AASHTO Test Method	RS-2	HFRS-2	AE-90	AE-90S	AE-T	AE-150	AE-150L	AE-PL	AE-PMT [6]	AE-PMP [6]
Test on Emulsion											
Viscosity, Saybolt Furol at 25°C, min.	T 72			50			50				20+
Viscosity, Saybolt Furol at 25°C, max.	T 72					100		100	115	100	
Viscosity, Saybolt Furol at 50°C, min.	T 72	75	75		50		75				
Viscosity, Saybolt Furol at 50°C, max.	T 72	400	400				300				
Demulsibility w/35 mL, 0.02N CaC12, %, min.	T 59	50	50		30						
Demulsibility w/50 mL, 0.10N CaC12, %, min.	T 59			75		75				25+	25+
Oil Distillate by Distillation, mL/100 g Emul [3]	T 59	4.0	4.0	4.0	3.0	4.0	7.0	7.0	3.0	3.0	3.0
Residue by Distillation, %, min.	T 59	68	68	68	65 [5]	54	68	60	30		
Residue by Distillation, % max.	T 59					62		65			
Sieve Test, %, max.	T 59	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Penetrating Ability, mm, min.	902.02(w)								6		
Stone Coating Test, %	902.02(t)3a			90			90	90			
Settlement, %, max.	T 59	5	5	5							
Storage Stability, %, max.	T 59				1						
Asphalt Content by Distillation at 204°C, %, min.										54	45
Asphalt Content by Distillation at 204°C, %, max.										62	
Tests on Residue											
Penetration (0.1 mm) at 25°C, 100g, 5 s, min. [4]	T 49	100	100	100	90	50			*40* [7]	50	300+
Penetration (0.1 mm) at 25°C, 100g, 5 s, max. [4]	T 49	200	200	200	150	200			*90* [7]	200	
Penetration (0.1 mm) at 25°C, 50g, 5 s, min. [4]	T 49						100	100			
Penetration (0.1 mm) at 25°C, 50g, 5 s, max. [4]	T 49						300	300			
Ductility at 25°C, mm, min.	T 51	400	400	400		400					
Solubility in Org. Sol., %, min.	T 44	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5
Float Test at 50°C, s, max. (4)	T 50										
Float Test at 60°C, s, min. (4)	T 50		1200	1200	1200	1200	1200	1200			
Force Ratio	T 300				0.3						
Elastic Recovery, at 4°C	T 301				58						
Polymer Content by Infrared										1.5+	1.5+

Notes:
(1) Broken samples or samples more than 10 days old will not be tested.
(2) Combined percentage of the residue and oil distillate by distillation shall be at least 70% (note the different units – ml for oil and % for residue).
(3) Oil distillate shall be in accordance with ASTM D 396, table 1, grade no. 1
(4) The Engineer may waive the test.
(5) Maximum temperature to be held for 15 minutes 200 ± 5°C.
(6) Asphalt shall be polymerized prior to emulsification.
(7) The indicated penetration values shall apply to AE-PL used for fog seal (Section 412).

SECTION 902, CONTINUED.

Other sections containing specific cross references:

403.02 Pg 252
404.02 Pg 254
406.02 Pg 259
408.02 Pg 261
507.02 Pg 325

Recurring Special Provisions potentially affected:

None

Motion: Mr. Walker
Second: Mr. Cales
Ayes: 10
Nays: 0

General Instructions to Field Employees
Update Required? No

Frequency Manual
Update Required? No

Standard Sheets potentially affected:

None

Action: Passed as submitted

_x_ RSP Effective July 1, 2008 Letting
___ RPD Effective: ____________ Letting
___ 20__ Standard Specifications Book
___ 20__ Standards Edition
___ 20__ Design Manual
___ Technical Advisory

Received FHWA Approval? Yes

SECTION 911, BEGIN LINE 3, INSERT AS FOLLOWS:

911.01 Untreated Lumber

(a) General

Untreated limber is a saw mill product which is not further manufactured than by sawing, resawing, passing lengthwise through a standard planning machine, *drying,* cross cutting to length, and machining but is not treated with preservatives.

SECTION 911, BEGIN LINE 34, INSERT AS FOLLOWS:

4. *Sawn* Timbers

Lumber of 5 in. (125 mm) or more in the least dimension is timber. Timbers may be classified as beams, stringers, posts, caps, sills, girders, purlins, etc. Timber for structural purposes shall be no less than 6 in. (150 mm) in width or thickness. Dimensions and grade of lumber shall be as shown on the plans or as otherwise specified.

SECTION 911, BEGIN LINE 56, DELETE AND INSERT AS FOLLOWS:

8. Rough *Sawn* Lumber

~~Lumber as it comes from the saw is rough lumber.~~ *This is lumber that has been sawn, edged, and trimmed, but not dressed.*

COMMITTEE COMMENTS ON THIS ITEM:

This item is necessary to make specification wording consistent with AASHTO LRFD Bridge Construction Specification, 2nd Edition.

RSP not needed. Add to 2010 Specifications.

Other sections containing specific cross references:
601.02 Pg 339
712.02 Pg 534
911.02(a) Pg 803
911.02(c) Pg 803

Recurring Special Provisions potentially affected:

None

Motion: Ms. Rearick
Second: Mr. Cales
Ayes: 10
Nays: 0

General Instructions to Field Employees
Update Required? No

Frequency Manual
Update Required? No

Standard Sheets potentially affected:

None

Action: Passed as submitted

___ RSP Effective: ____________ Letting
___ RPD Effective: ____________ Letting
_x_ 2010 Standard Specifications Book
___ 20__ Standards Edition
___ 20__ Design Manual
___ Technical Advisory

Received FHWA Approval? Yes

Item No. 08-6-5
Ms. Rearick
Date: 01/17/08

REVISION TO DESIGN MANUAL

PART VI, STRUCTURAL DESIGN: CHAPTERS 61, 62, 63, 65, 67
61.6-02(03)
61-6.06(01)
62-1.04
62-1.06
62-3.16
63-3.04
63-6.06
63-6.07
63-6.08
65-3.01
65-3.03
67-3.03

COMMITTEE COMMENTS ON THIS ITEM:

Motion made that Committee approve Indiana Design Manual changes be made to comply with AASHTO LRFD Bridge Construction Specifications, 2nd Edition.

Indiana Design Manual changes that do not require changes to Standard Specifications or Standard Drawings do not require Standards Committee approval.

Attached Design Manual changes were not reviewed by Committee.

Other sections containing specific cross references:

None

Recurring Special Provisions potentially affected:

None

Motion: Ms. Rearick
Second: Mr. Cales
Ayes: 10
Nays: 0

General Instructions to Field Employees
Update Required? No

Frequency Manual
Update Required? No

Standard Sheets potentially affected:

None

Action: Passed as revised

___ RSP Effective: ____________ Letting
___ RPD Effective: ____________ Letting
___ 20__ Standard Specifications Book
___ 20__ Standards Edition
_x_ 2008 Design Manual
___ Technical Advisory

Received FHWA Approval? Yes

61-6.02(03) Considerations if Sidewalk Present

2. Design Speed of 80 km/h 50 mph or Higher. The bridge railing cannot be placed at the coping side of the sidewalk, therefore it must be placed between the roadway and the sidewalk. A pedestrian- or bicycle railing should then be placed at the coping side of the sidewalk. ~~as described below. The height of the vehicular bridge railing between the roadway and the sidewalk must meet or exceed the minimum height requirement of a pedestrian railing, 1070 mm, or a bicycle railing, 1370 mm, whichever applies.~~ Where the vehicular bridge railing is placed between the roadway and the sidewalk, the sidewalk need not be raised; i.e., the roadway surface and sidewalk surface may be at the same elevation. However, the sidewalk drainage pattern should be reviewed. The guardrail transition and bridge-railing transition should be connected to the pedestrian railing. An impact attenuator type R1 should be connected to the bridge railing.

61-6.06(01) Bicycle Path

This is defined as a bikeway physically separated from motorized vehicular traffic by an open space or barrier and either within the highway right-of-way or within an independent right-of-way. Each bridge which is a part of a bicycle path will require bicycle railing of ~~1370 mm~~ *1070 mm 3.5 ft* height.

62-1.04 Shear And Torsion

In a region near a discontinuity, such as an abrupt change in cross-section, opening, coped (dapped) end, deep beam, ~~or~~ corbel, *or where the shear stress at the design section is greater than 0.18f_c' and is not built integrally with the support,* the strut-and-tie model should be used. See *LRFD* Articles 5.6.3 and 5.13.2.

LRFD Article 5.8.3 discusses the sectional-design model. Subsections 1 and 2 describe the applicable geometry required to use this technique to design web reinforcement.

The nominal resistance is taken as the lesser of the following:

$$V_n = V_c + V_s + V_p \qquad \text{(LRFD Eq. 5.8.3.3-1)}$$

or

$$V_n = 0.25\,f'_c\,b_v d_v + V_p \qquad \text{(LRFD Eq. 5.8.3.3-2)}$$

For a non-prestressed section, $V_p = 0$.

LRFD Equation 5.8.3.3-2 represents an upper limit of V_n to ensure that the concrete in the web will not crush prior to yield of the transverse reinforcement.

The nominal shear resistance provided by tension in the concrete*, if the procedure described in LRFD 5.8.3.4.1 or 5.8.3.4.2 is used,* is computed as follows:

$$V_c = 0.083\beta\sqrt{f'_c}\,b_v d_v \qquad \text{(LRFD Eq. 5.8.3.3-3)}$$

If the procedure described in LRFD 5.8.3.4.3 is used, V_c is the lesser of V_{ci} or V_{cw}.

The contribution of the web reinforcement is computed as follows:

$$V_s = \frac{A_v f_y d_v \left(\cot\theta + \cot\alpha\right)\sin\alpha}{s} \qquad \text{(LRFD Eq. 5.8.3.3-4)}$$

Where the angles, θ and α, represent the inclination of the diagonal compressive forces measured from the horizontal beam axis and the angle of the web reinforcement relative to the horizontal beam axis, respectively. *If the procedure described in LRFD 5.8.3.4.3 is used, cot θ is defined therein.*

62-1.06 Fatigue

References: Articles 3.4.1, 3.6.1.4, and 5.5.3

The fatigue limit state is not normally a critical issue. Fatigue need not be considered for the deck where the permanent stress, f_{min}, is compressive~~ and exceeds twice the maximum tensile live load stress~~.

~~Assuming *r/h* = 0.3,~~ LRFD Equation 5.5.3.2-1 may be rearranged for easier interpretations as follows:

$$f_f + 0.33\, f_{\min} \ \leq \ 161.5\ MPa$$

The ~~LRFD Specifications shows a change in computing~~ *value of* f_f ~~. It~~ is the stress range due to 75% of a single truck per bridge (lane load excluded) with reduced impact (15%) and with the major axles of the truck at a constant spacing of 9 m 30 ft, instead of all contributing lanes being loaded. Also, the LRFD Specifications specifies that, if the bridge is analyzed by the approximate distribution method, live-load distribution factors for one design lane loaded should be used.

62-3.16 Fatigue-Limit State

Reference: Article 5.5.3

The fatigue-limit state does not control the area of steel required at the points of maximum moment. However, it may control at bar cut-off points. The stress range, f_f, *in straight reinforcement and welded-wire reinforcement without a cross weld in the high-stress region resulting from the fatigue-load condition* must satisfy the following:

$$\cancel{f_f \le 145 - 0.33 f_{\min} + 55\left(\frac{r}{h}\right)} \text{.........} \; f_f \le 165 - 0.33 f_{\min} \text{ .... (LRFD Eq. 5.5.3.2-1)}$$

The stress range, f_f, in straight welded-wire reinforcement with a cross weld in the high-stress region resulting from the fatigue-load condition must satisfy the following:

$$f_f \le 110 - 0.33 f_{\min} \qquad \textit{(LRFD Eq. 5.5.3.2-2)}$$

The value of f_{min} is the minimum live-load stress resulting from the fatigue load combined with the more-severe stress from either the permanent loads or the permanent, shrinkage, and creep-induced external loads; positive if tension, negative if compression.

The definition of the high-stress region for application of LRFD Equation 1 or 2 for flexural reinforcement should be taken as one-third of the span on each side of the section of maximum moment.

The section properties should be based on a cracked section where the sum of the stresses due to unfactored permanent loads plus 1.5 times the fatigue load is tensile and exceeds $0.25\sqrt{f'_c}$. A section in a stress-reversal area should be analyzed as a doubly-reinforced section.

63-3.04(01) Elastic Shortening

Once the strands at the ends of a pretensioned member are cut, the prestress force is transferred to and produces compression in the concrete. The compressive force on the concrete causes the member to shorten with an accompanying loss of prestress.

The loss in prestress due to elastic shortening in a pretensioned member should be computed by means of *LRFD Specifications* Equation 5.9.5.2.3a-1. The following modulus of elasticity values should be used.

a. E_p = 197,000 MPa, the modulus of elasticity of the prestressing steel (*LRFD* Article 5.4.4.2).

b. $\cancel{E_{ci}}$ $E_{ct} = 4800\sqrt{f'_c}$, the modulus of elasticity of concrete at transfer ~~of the prestressing force (*LRFD* Eq. C5.4.2.4-1)~~ *or time of load application*.

If the centroid of the prestressing force is below the centroid of the concrete member, the member will be lifted upward at transfer, and the self-weight of the member will be activated. The concrete stress at the centroid of the prestressing tendons is identified through the following equation.

$$f_{cgp} = \frac{P_i}{A_c} + \frac{e}{I_c}\left(P_i e - M_b\right)$$

where:

P_i = prestressing force at transfer
A_c = area of the concrete beam
I_c = moment of inertia of concrete beam
e = eccentricity of prestressing steel at midspan
M_b = moment at midspan due to self-weight of beam

The force P_i will be slightly less than the transfer force because these stresses will be reduced as a result of the elastic shortening of the concrete and the relaxation of tendons between the time of jacking and transfer.

This requires the use of a trial-and-error process of design iterations. *LRFD* Article 5.9.5.2.3a allows P_i to be based on a prestressing tendon stress of $0.70f_{pu}$ for low-relaxation strands.

Strands that are placed in the top flange of the beam for the purpose of reducing the tensile stresses may be neglected for the determination of prestress losses due to elastic shortening.

As an alternative to the above method of calculation, *PCI Bridge Design Handbook* Section 8.6.7.1 provides for an alternative method of calculating elastic-shortening losses.

For a post-tensioned member, there will be no loss of prestress due to elastic shortening if all of the tendons are tensioned simultaneously. No loss occurs because the post-tensioning force compensates for the elastic shortening as the jacking operation progresses. If the tendons are tensioned sequentially, the first tendon anchored will experience a loss due to elastic shortening equal to that specified above for a pretensioned member.

Each subseqent tendon that is post-tensioned will experience a fraction of the pretensioned loss, with the last tendon anchored having no loss. The average post-tensioned loss is one-half of the pretensioned loss if the last tendon also has a loss. Because the last tendon does not have a loss, the loss of prestress due to elastic shortening for a post-tensioned member is provided by *LRFD Specifications* Equation 5.9.5.2.3b-1.

63-3.04(02) Shrinkage

Shrinkage of concrete is a time-dependent loss of prestress that is influenced by the curing method used, the volume-to-surface ratio of the member, the water/cement ratio of the concrete mix, and the ambient relative humidity, *H*.

The *LRFD Specifications* provides expressions for prestress loss due to shrinkage, Δf_{pSR}, ~~that are a function of average *H*, and are shown~~ as Equations 5.9.5.4.2-1 and 5.9.5.4.2-2 ~~for a pretensioned and a post-tensioned member, respectively. *H* may be taken as 70%, which results in a shrinkage loss of 45.0 MPa for a pretensioned member, or 33.5 MPa for a post-tensioned member~~.

~~For a post-tensioned member, the shrinkage loss in the tendons will be less than that for a pretensioned member because the concrete has additional drying time before the prestress is applied.~~

The percent gain due to shrinkage of the deck composite section, Δf_{pSR}, is determined from LRFD Equation 5.9.5.4.3d-1.

63-3.04(03)Creep

Creep of concrete is a time-dependent phenomenon in which deformation increases under constant stress due primarily to viscous flow of the hydrated cement paste. Creep depends on the age of the concrete, the type of cement, the hardness of the aggregate, the proportions of the concrete mixture, and the method of curing. The additional long-time concrete strains due to creep can be more than twice the initial strain at the time load is applied.

The expression for prestress loss due to creep is a function of the concrete stress at the centroid of the prestressing steel at transfer, f_{cgp}. The change in concrete stress at the centroid of the prestressing steel ~~due to all permanent loads except those present at transfer,~~ $\cancel{\Delta f_{cdp}}$ *between the time of deck placement and final time,* Δf_{pCR}, is shown in *LRFD Specifications* Equation 5.9.5.4.3*b*-1. Equation 5.9.5.4.3*b*-1 utilizes the same value of $\cancel{f_{cdp}}$ f_{cgp} as defined and discussed in *LRFD* Article 5.9.5.2.3. The value of $\cancel{\Delta f_{cdp}}$ Δf_{pCR} is computed by applying the deck weight and the weight of interior diaphragms to the non-composite section and the composite dead loads to the composite section. The wearing-surface dead load, which will be applied during the initial construction, should be included in the composite dead loads. However, a future wearing surface should not be included. The values of f_{cgp} and $\cancel{\Delta f_{cdp}}$ Δf_{pCR} should be calculated at the point of maximum moment.

This prestress loss due to creep can be used for a prestressed-concrete member. The stress value's algebraic sign is based on the situation where the tendon eccentricity, *e*, is below the center of gravity of the section and opposing the dead load moments. Strands that are placed in the top flange of the beam for the purpose of reducing the tensile stresses may be neglected for the determination of prestress losses due to creep.

63-3.04(04) Relaxation

Relaxation of the prestressing tendons is a time-dependent loss of prestress that occurs if the tendon is held at constant strain. The total relaxation loss Δf_{pR} is separated into the two components as follows:

$$\Delta f_{pR} = \Delta f_{pR1} + \Delta f_{pR2}$$

where Δf_{pR1} is the relaxation loss ~~at~~ *between time of* transfer ~~of the prestressing force~~ *and deck placement*, and Δf_{pR2} is the relaxation loss ~~after transfer~~ *between time of deck placement and final time*.

The ~~prestress loss due to~~ relaxation ~~at transfer~~ *loss*, Δf_{pR1}, ~~for a pretensioned member~~ should be computed from *LRFD Specifications* Equation~~s 5.9.5.4.4b-1 or 5.9.5.4.4b-2 for stress-relieved or low-relaxation strands, respectively~~ *5.9.5.4.2c-1*.

~~The initial jacking stress,~~ $\cancel{f_{pj}}$, ~~is~~ $\cancel{0.75 f_{pu}}$ ~~for low-relaxation strands, or~~ $\cancel{0.70 f_{pu}}$ ~~for stress-relieved strands (*LRFD Specifications* Table 5.9.3-1). The yield strength of prestressing steel,~~ $\cancel{f_{py}}$, ~~for stress-relieved or low-relaxation strands should be taken from *LRFD*~~

~~*Specifications* Table 5.4.4.1-1. For either stress-relieved or low-relaxation strands, the strand tensile strength, f_{pu}, is 1860 MPa. The time, t, between anchoring of the stressed strands and the transfer of prestress to the member should be taken as 18 h (0.75 day) for pretensioned beams.~~

~~Determining and substituting the values for f_{pj}, f_{py}, and t into Equations 1 and 2 yields the following:~~

$$\Delta f_{pR1} = \frac{\log(24.0t)}{10}\left[\frac{f_{pj}}{f_{py}} - 0.55\right] f_{pj} = \frac{\log(24.0 \text{ x } 0.75)}{10}\left[\frac{1302}{1581} - 0.55\right] 1302 = 44.7 \text{ MPa}$$

[Above equation should be overstruck]

~~for stress-relieved strands, or~~

$$\Delta f_{pR1} = \frac{\log(24.0t)}{40}\left[\frac{f_{pj}}{f_{py}} - 0.55\right] f_{pj} = \frac{\log(24.0 \text{ x } 0.75)}{40}\left[\frac{1395}{1674} - 0.55\right] 1395 = 12.4 \text{ MPa}$$

[Above equation should be overstruck]

~~for low-relaxation strands.~~

The relaxation loss, Δf_{pR1}, which is small, should be added to the computed elastic shortening loss, Δf_{pES}, in determining the initial prestress loss used to check beam stresses at transfer.

The *LRFD Specifications* commentary states that relaxation losses prior to transfer are accounted for during fabrication of a prestressed member. However, this is not standard practice. The only adjustments to the prestressing force that are made by beam producers are those required for temperature compensation, bed or form deformation, and chuck seating.

The ~~prestress loss due to~~ relaxation ~~after transfer for stress-relieved strands~~ *loss*, Δf_{pR2}, is 138 MPa, which is reduced continually with time as the other prestress losses reduce the tendon stress. The elastic shortening loss, Δf_{pES}, occurs almost instantaneously so that its effect is largest. The losses due to shrinkage, Δf_{pSR}, and creep, Δf_{pCR}, take place over a period of time and have a smaller effect. The losses due to friction, Δf_{pF}, for a post-tensioned beam, are between the two. The ~~prestress loss due to~~ relaxation ~~after transfer for stress-relieved strands~~ *loss*, Δf_{pR1}, should be computed from *LRFD Specifications* Equation ~~5.9.5.4.4c-1 or 5.9.5.4.4c-2 for a pretensioned and a post-tensioned member, respectively. For low-relaxation strands, use 30% of Δf_{pR2} indicated by Equation 1 or 2~~ *5.9.5.4.3c-1*.

63-6.06 Horizontal-Interface Shear

1. <u>Concrete-Members Structure</u>. A cast-in-place concrete deck designed to act compositely with precast-concrete beams must be able to resist the horizontal shearing forces at the interface between the two elements. ~~The following formula may be used to determine V_h.~~

$$\cancel{V_h = \frac{V_u}{d_e}} \quad \text{..........} \quad \cancel{(\textit{LRFD}\ \text{Equation C 5.8.4.1-1})}$$

~~The required strength should be less than or equal to the nominal strength and is as follows:~~

$\cancel{V_h A_{cv} \leq \Phi V_n}$

~~where $V_n = cA_{cv} + \mu[A_{vf}f_y + P_c]$. P_c, the permanent net compressive force normal to the shear plane, may be conservatively neglected.~~

The factored interface shear resistance, V_{ri}, is determined as follows:

$$V_{ri} = \varphi V_{ni} \quad \text{..........} \quad \textit{(LRFD Equation 5.8.4.1-1)}$$

Where: φ *= resistance factor for shear described in LRFD 5.5.4.2.1*

V_{ni} *= nominal interface shear resistance (kN).*

V_{ni} *should be taken as follows:*

$$V_{ni} = cA_{cv} + \mu\left(A_{vf} f_y + P_c\right) \quad \text{..........} \quad \textit{(LRFD Equation 5.8.4.1-3)}$$

Where: c *= cohesion factor specified in LRFD 5.8.4.3 (MPa)*

A_{cv} *= area of concrete considered to be engaged in interface shear transfer (mm^2)*

μ *= friction factor specified in LRFD 5.8.4.3*

A_{vf} *= area of interface shear reinforcement crossing shear plan within A_{cv} (mm^2)*

f_y *= yield stress of reinforcement (MPa)*

P_c *= permanent net compressive force normal to shear plane (kN).*

V_{ni} *should not be greater than the lesser of the following:*

$$K_1 f'_c A_{cv} \quad \text{..........} \quad \textit{(LRFD Equation 5.8.4.1-4)}$$

$$\text{or, } K_2 b_{vi} L_{vi} \quad \text{..........} \quad \textit{(LRFD Equation 5.8.4.1-5)}$$

Where: K_1 *= fraction of concrete strength available to resist interface shear*
K_2 *= limiting interface shear resistance specified in LRFD 5.8.4.3*
b_{vi} *= interface width considered to be engaged in shear transfer (mm)*
L_{vi} *= interface length considered to be engaged in shear transfer (mm).*

The longitudinal spacing of rows of interface shear-transfer reinforcing bars should not exceed 600 mm.

2. *Concrete-Slab Bridge*. ~~*LRFD* Article 5.8.4.2 indicates that for concrete placed against clean hardened concrete with the surface intentionally roughened to an amplitude of 6 mm, the tops of the beams should be scored at 75-mm centers transverse to the top beam flange to a depth of at least 6 mm.~~

~~c = 0.70 MPa~~
~~μ = 1.0 λ, where λ = 1.0 for normal density concrete~~

~~Therefore, for normal-weight concrete cast against hardened, roughened, normal-weight concrete, the above relationship may be reduced as follows:~~

$$\cancel{V_h \le \Phi\left[0.7 + \frac{A_{vf} f_y}{A_{cv}}\right]}$$

~~where the minimum~~ $\cancel{A_{vf} \ge \frac{0.35 f_y}{A_{cv}}}$.

~~The nominal shear resistance, V_n, used in the design should satisfy one of the following:~~

~~$V_n \le 0.2 f_c' A_{cv}$ .... (LRFD Equation 5.8.4.1-2)~~

~~$V_n \le 5.5 A_{cv}$ .... (LRFD Equation 5.8.4.1-3)~~

~~If the width of the interface surface is more than 1200 mm, a minimum of four #13 bars should be used for each row with two of the bars, one on each side of the flange, located near the outside edge of the flange. *LRFD* Article 5.8.4.1 requires that the maximum spacing of horizontal shear stirrups not exceed 600 mm. For a member such as a partial-depth deck panel, the minimum reinforcement requirement of A_{vf} may be waived if V_n/A_{cv} is less than 0.7 MPa.~~

The factored interface shear stress, v_{ui}*, is determined as follows:*

$$v_{ui} = \frac{V_{ul}}{b_{vi} d_v} \qquad \text{(LRFD Equation 5.8.4.2-1)}$$

Where: V_{ul} *= factored interface shear force (kN)*
d_v *= distance between the centroid of the tension steel and the midthickness of the slab (mm).*

The factored interface shear force, V_{ui}*, is determined as follows:*

$$V_{ui} = v_{ui} A_{cv} = 12 v_{ui} b_{vi} \qquad \text{(LRFD Equation 5.8.4.2-2)}$$

If the net force, P_c *(kN), across the interface shear plane is tensile, additional reinforcement,* A_{vpc} *(*mm^2*), should be provided based on the following:*

$$A_{vpc} = \frac{P_c}{\phi f_y} \qquad \text{(LRFD Equation 5.8.4.2-3)}$$

63-6.07 Continuity for Superimposed Loads

The traditional method of making simply-supported beams continuous is to construct a ~~closure joint~~ *continuity diaphragm* between the adjacent beam ends over the pier, conveniently as part of the diaphragm, and to place extra longitudinal steel in the deck over the pier support to resist the negative moment. Spans made continuous for live load are assumed to be treated as prestressed members in the positive moment zone between supports and as conventionally-reinforced members in the negative-moment zones over the support. The reinforcing steel in the deck should carry all of the tension in the composite section due to the negative moment. The longitudinal reinforcing steel in the deck that makes the girder continuous over an internal support should be designed in accordance with LRFD Article 5.14.1.2.7b.

63-6.08 Effect of Imposed Deformations

Where beams are made continuous at the relatively young age of less than ~~120~~ *90* days from time of manufacture, it is more likely that positive moments will develop with time at the supports. These positive restraint moments are the result of the tendency of the beams to continue to camber upwards as a result of ongoing creep strains associated with the transfer of prestress. Shrinkage of the deck concrete, loss of prestress, and creep strains due to self-weight, deck weight, and superimposed dead loads all have a tendency to reduce this positive moment.

The simplified method referenced in LRFD Article 5.14.1.4.4 may be used if the beam has a minimum age of 90 days once continuity is established.

65-3.01 General

The design of wood components includes a number of ~~modification~~ *adjustment* factors not normally associated with steel or concrete. Some of these factors address the variability inherent in wood. Others concern the response of the wood member to all of the environmental factors under which it is to perform. Most of these factors are applied to the ~~base resistance~~ *reference design value* side of the design equation.

One of the ~~modification~~ *adjustment* factors unique to wood-bridge design is the deck factor, ~~C_D~~ C_d. This factor recognizes the load sharing between individual members under certain circumstances. It is applied only to solid sawn members, ~~50 to 100 mm~~ 2 to 4 in. thick, that are used in a structural system that creates load sharing between individual members. LRFD Specifications Article ~~8.4.4.4~~ *8.4.4.8* recognizes only two applications for this factor, stressed-wood and nail-laminated/spike-laminated wood decks.

Another ~~modification~~ *adjustment* factor is the ~~moisture content~~ *wet-wood service* factor, C_M, as used and specified in LRFD Specifications Article 8.4.4.3. Glue-laminated wood is considered to be wet if the in-service moisture content is ~~greater~~ *less* than *or equal to* 16%. For such condition, $C_M = 1.0$. If the in-service moisture content is ~~less~~ *greater* than 16%, as indicated in ~~LRFD Specifications Table 8.4.4.3-1~~ *Figure 65-3A, Service Factor for Wet Glue-Laminated Wood*, the value for C_M is ~~greater~~ *less* than 1.0.

Resistance Design Value, Flexure, F_{bo}	*Resistance Design Value, Shear, F_{vo}*	*Resistance Design Value, Tension, F_{to}*	*Resistance Design Value, Compression, Perpendicular to Grain, F_{co}*	*Resistance Design Value, Compression, Parallel to Grain, F_{cpo}*	*Modulus of Elasticity, E_o*
0.80	*0.875*	*0.80*	*0.73*	*0.53*	*0.833*

SERVICE FACTOR, C_M, FOR WET GLUE-LAMINATED WOOD

Figure 65-3A

65-3.03 Spike-Laminated Deck

The deck is made using a category of solid sawn members classified as dimension lumber. These are planks that are 50 to 100 mm 2 to 4 in. in thickness and range in width from 200 to 400 mm 8 to 16 in. The ~~base resistance~~ *reference design* value for this material is shown in *LRFD* Table 8.4.1.1.4-1. The correct size classification should be used for the material in question. The table includes ~~base resistance~~ *reference design* values for size classifications including beams and stringers (B&S), post and timbers (P&T), and dimension lumber. The individual members are cut to length and drilled for the connection hardware prior to treatment with an approved wood preservative.

13. Reinforcing-Steel Splicing. If a pier stem is less than 3 m 10 ft height, do not splice the steel extending out of the footing. For small columns with a high percentage of vertical steel and for columns in Seismic Zone 2, mechanical connectors should be used for splicing the vertical steel. *See LRFD Article 5-10-11-4-1f for splice-length requirements.*

14. Compression Reinforcement. Compression steel tends to buckle once the concrete cover is gone or where the concrete around the steel is weakened by compression. The criteria in *LRFD Specifications* Articles 5.7.4.6, 5.10.6, or 5.10.11, for ties or spirals should be used. See Figure 67-3F for suggested hammerhead and wall-type pier reinforcing in columns with no plastic hinging capability. Ties may be #10 #3 bars for longitudinal bars up to size #32 #10.

15. *Seismic Hoop. This consists of a cylindrical noncontinuously wound tie with closure made using a butt weld or a mechanical coupler. Seismic hoops may be used in Seismic Zone 2 for an end bent or column bent at the top or bottom of a column in combination with spirals, or for the full height of a column in lieu of spirals. They should be used in lieu of spirals for a pier.*

Seismic hoops improve constructability where the transverse reinforcement cage must extend up into a bent cap or down into a footing.